MARLEY

thermal science

Cooling Tower Performance

RANGE

When discussing cooling tower performance, a common misconception arises in assuming the cooling tower determines the temperature difference between the hot and cold water. In reality the cooling tower determines the difference between the cold water and entering wet bulb temperatures otherwise known as the *approach*. The wet bulb temperature is the temperature of the air if it were saturated with water (100% relative humidity). **Figure 1** provides a visual representation of the relationship between *range* and *approach*. Please note that temperatures are for illustrative purposes only.

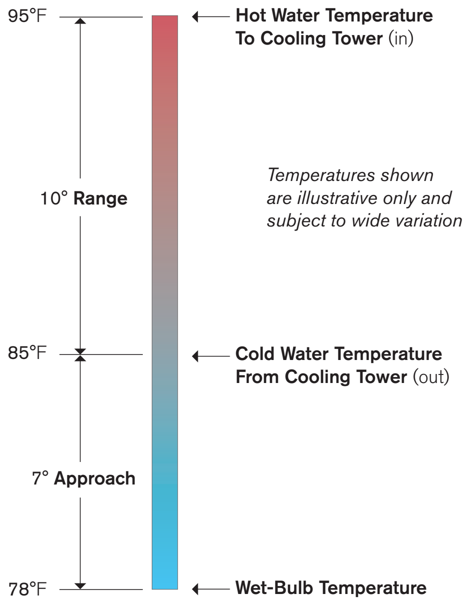

Figure 1 Relationship of temperatures related to cooling tower operation

To further explain the concept, consider a general industrial process which creates a specified heat load, usually measured in Btu/hr. Assuming steady-state process conditions, the heat load will change minimally with time. The process cooling water absorbs this specified heat load and takes it to the cooling tower. The heat load absorbed by the water is given by the equation:

$$Q = m \times c_p \times \Delta T$$

Where Q *= heat load of process*

m *= mass flow of water*

c_p *= specified heat of water (constant)*

ΔT *= change in temperature of water (range)*

Therefore the range is determined by the water flow rate and heat load at the exchanger in the process. The cooling tower is neither a heat sink nor heat source and thus the heat load is always constant. In other words, Q, m and c_p from the equation will generally stay the same over short periods of time. By deduction the range ΔT must be constant over that same time period.

Cooling tower performance therefore is not measured by the amount of heat that is rejected, but rather the outlet cold water temperature the process will observe. The cooling tower transfers all of the process heat into the atmosphere. A simple experiment to prove that the cooling tower only determines the approach involves operating a cooling tower at any constant heat load and turning the fans off. When the fans stop, the performance of the tower will diminish significantly due to the lack of airflow. After that point, the hot and cold water temperatures rise at the same rate, but the range does not change. This result is shown in **Figure 2**. Again, the given temperatures are for illustrative purposes only and do not reflect actual tower performance.

This simple demonstration shows that cooling tower performance is inversely proportional to the approach and is not determined by the range. Looking at the process as a whole, it can be shown that as the water from the cooling tower increases in temperature, the water entering the cooling tower will increase by the same amount. The temperatures of the inlet and outlet water from the cooling tower will continue to increase until the system reaches thermal equilibrium at some higher approach. Therefore the cooling tower is rejecting the same amount of heat as before, but at an elevated cold water temperature.

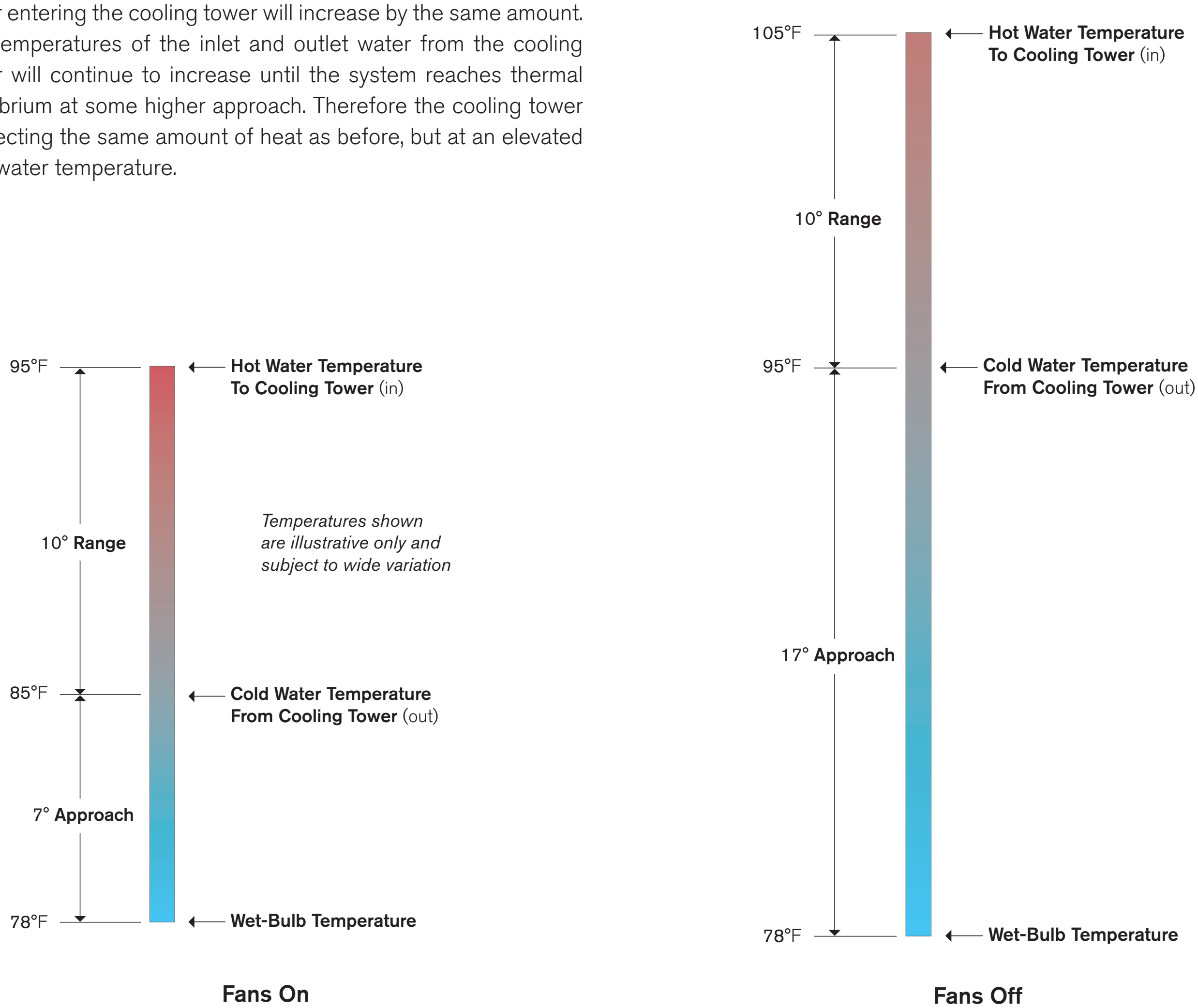

Figure 2 Effect of turning the tower fans off

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